Structures Research Update

M. H. Ansley Structures Research Center

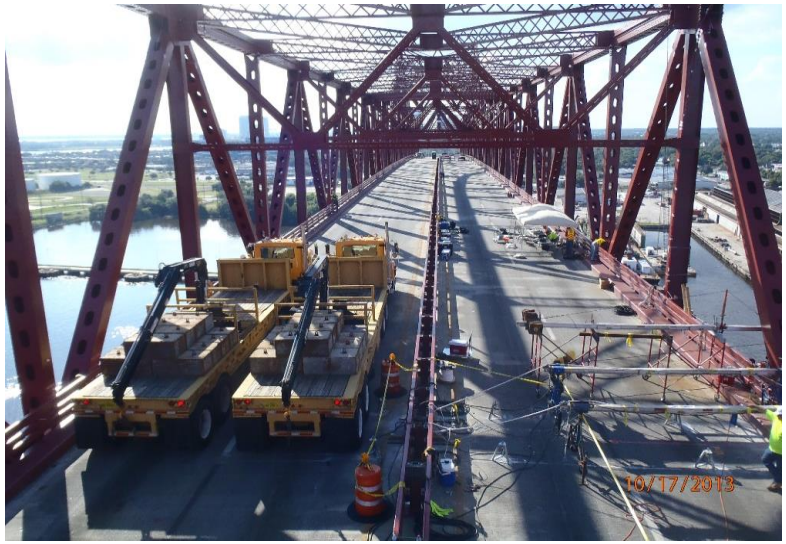
Will Potter

Presentation Outline

- FDOT Structures Research Center
- Flexible Filler (Unbonded PT Tendons)
- Aluminum Lightweight Deck
- External FRP Repair Durability
- Breakaway Sign
- Empirical Deck for Phased Construction and Widening
- Flat Slab Bridges

Structures Research Center

- Structures Research
  - Internal
  - University/Consultant
- Bridge Load Testing



Flexible Filler Research

- 3:15 pm this afternoon – Rick Vallier presenting

Aluminum Lightweight Deck

- Open Steel Grid Existing Concerns
  - Skid Resistance
  - Corrosion (Open)
  - Fatigue
  - Noise
  - Ride Quality
  - Bicycle Safety

Lightweight Aluminum Deck

- Alternatives Evaluation:
  - FRP, SPS, UHPC Waffle Deck, and Aluminum Orthotropic.
  - 40 Different Evaluation Criteria
  - Aluminum Deck Scored the Highest

- Advantages:
  - Solid Surface
  - Weight Neutral (21-22 psf)
  - Durability and Service Life
  - Configuration
  - Available Design Spec.
  - Material Familiarity
  - History
  - Research
  - Previous Installations

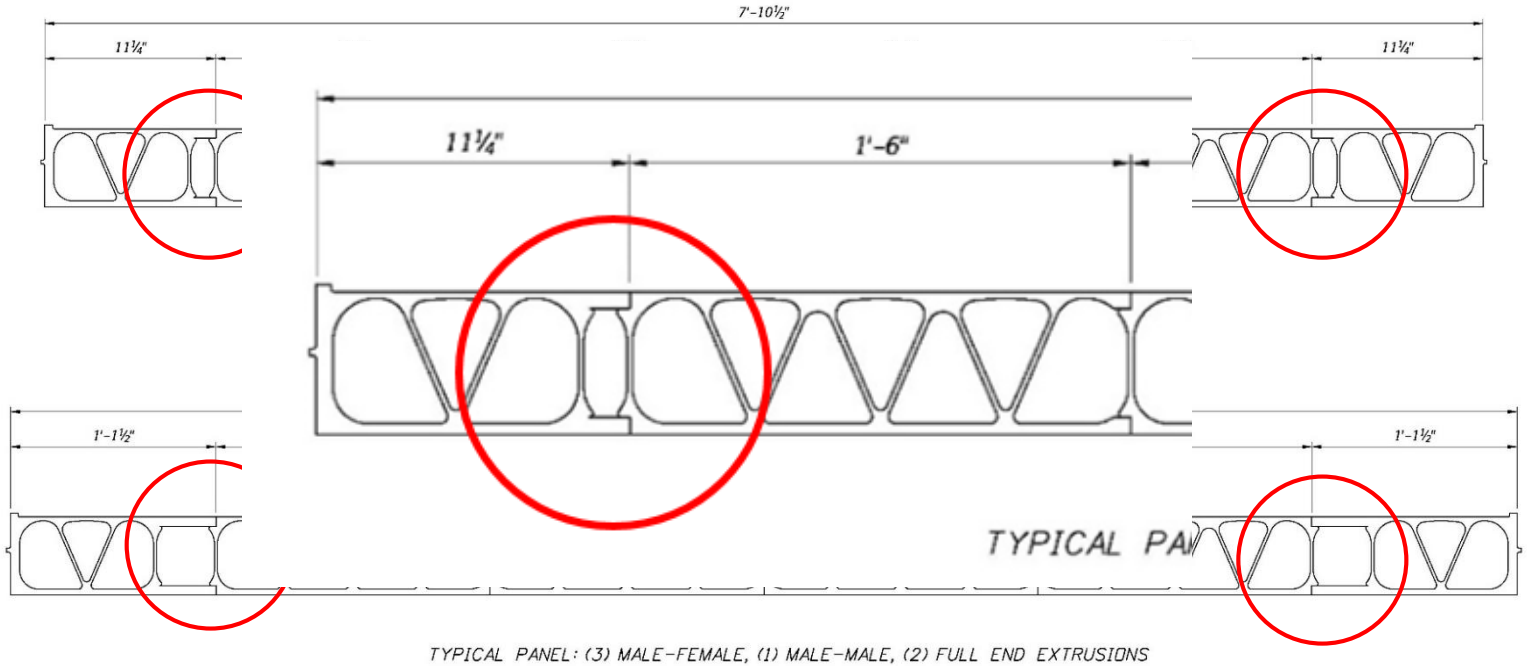
- Disadvantages:
  - High Initial Cost
  - New Use of Product
  - Coeff. Of Thermal Expansion
  - Wearing Surface
  - Galvanic Corrosion
  - Proprietary Product

Aluminum Lightweight Deck

- Evolution of the Deck Panels

Aluminum Lightweight Deck

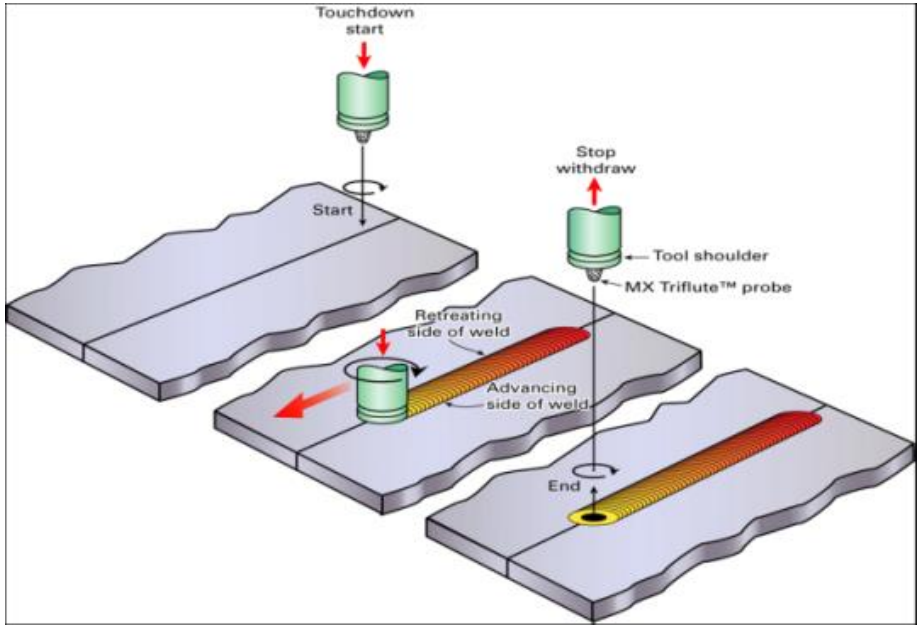
- Infinite Range of Panel Widths
- 32-ft Max Panel Length
- Extrusions Friction Stir Welded (FSW) to Create Panels

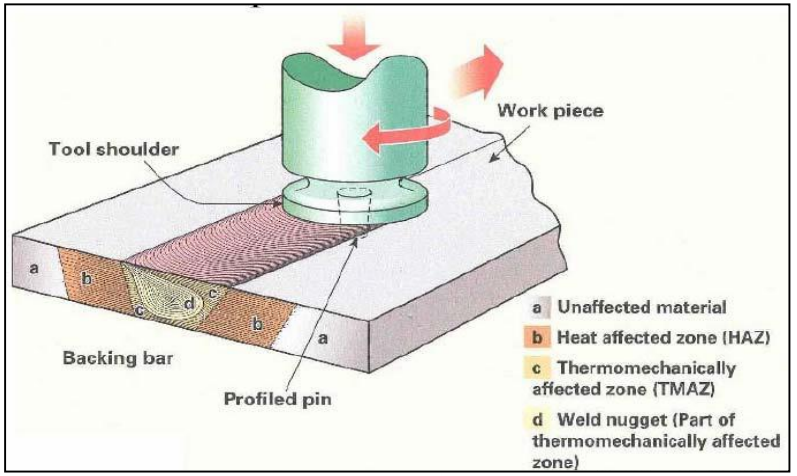


TYPICAL PANEL: (3) MALE-FEMALE, (1) MALE-MALE, (2) FULL END EXTRUSIONS
H&H PROPOSED PANEL DETAILS

Aluminum Lightweight Deck

- Friction Stir Welding (FSW)
  - Solid-State, Hot Shear Joining Process
  - Complex Thermo-Mechanical Process
    - Varying temperature (0.7 to 0.9 melting point)



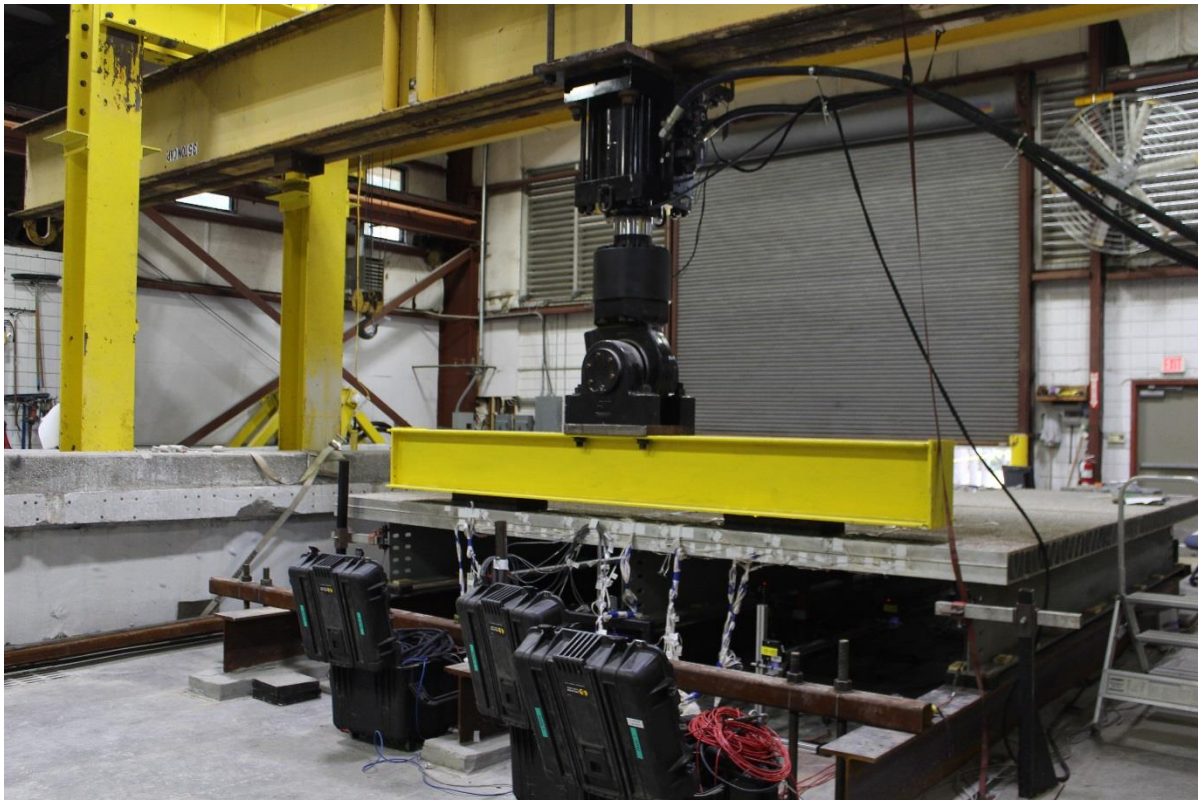


Aluminum Lightweight Deck

- Friction Stir Welding (FSW)
  - Higher Quality Joint
  - Flaws Possible
  - Various Items Influence Quality
  - Quality Control/Weld Inspection
    - AWS D1.2 Structural Welding Code – Aluminum (2014)

Aluminum Lightweight Deck

Aluminum Lightweight Deck



Aluminum Lightweight Deck

Aluminum Lightweight Deck

- Heavy Vehicle Simulator Testing
  - 11 kip wheel load
  - 600,000 cycles

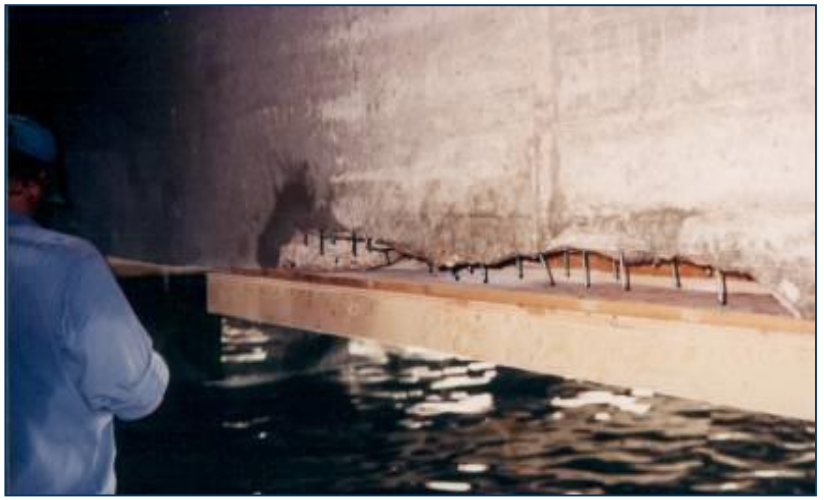
Aluminum Lightweight Deck

- Heavy Vehicle Simulator Testing

Durability of FRP Repairs

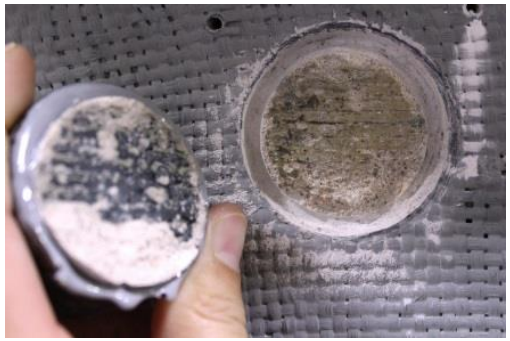
- Objective
  - Evaluate performance of FRP composite repair:
    - Added Strength
    - Durability
    - Effects on chloride concentrations

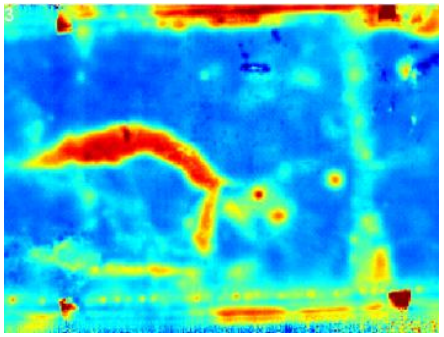
Durability of FRP Repairs



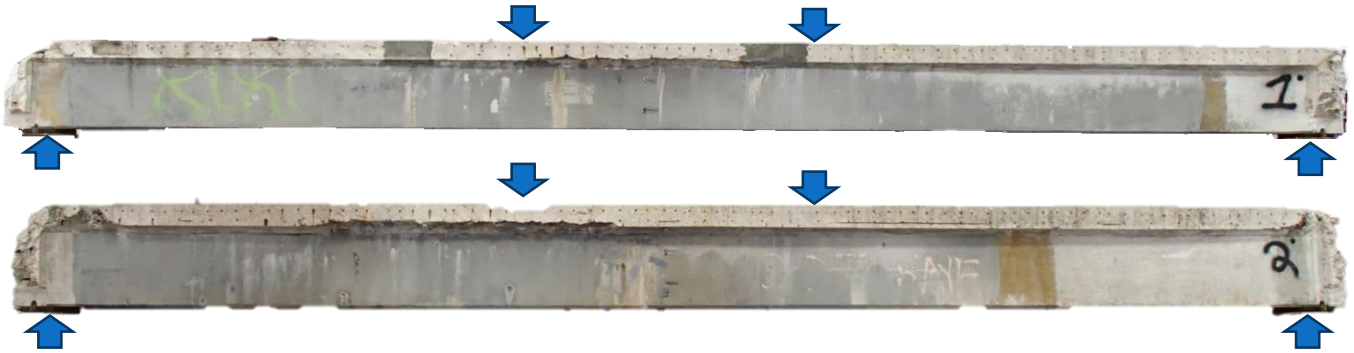
Durability of FRP Repairs

- Bond Pull-Off Test (ASTM)
- Infrared (IR) Scanning
- Chloride Cores
- Strength Cores
- Carbonation
- Steel Tensile Test
- FRP Tensile Test

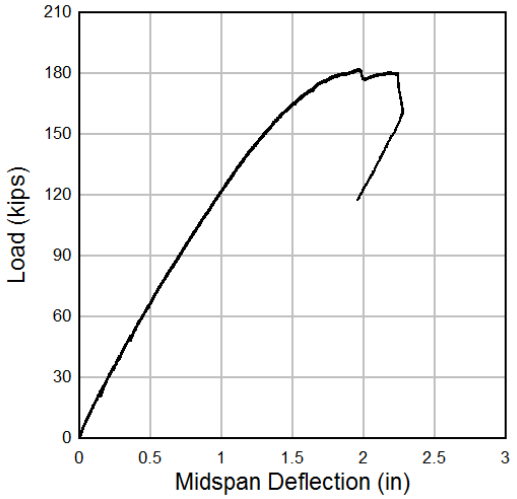




Durability of FRP Repairs

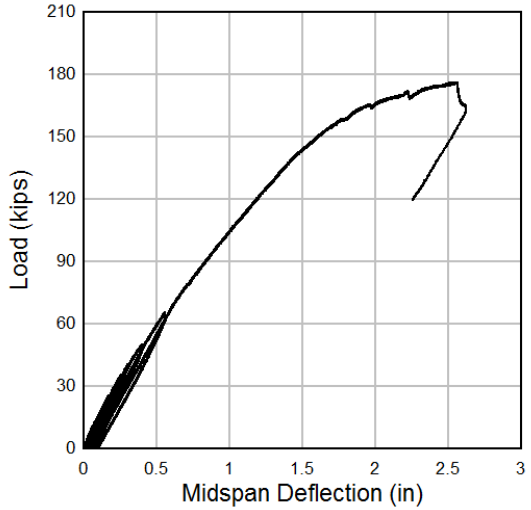


Girder #1



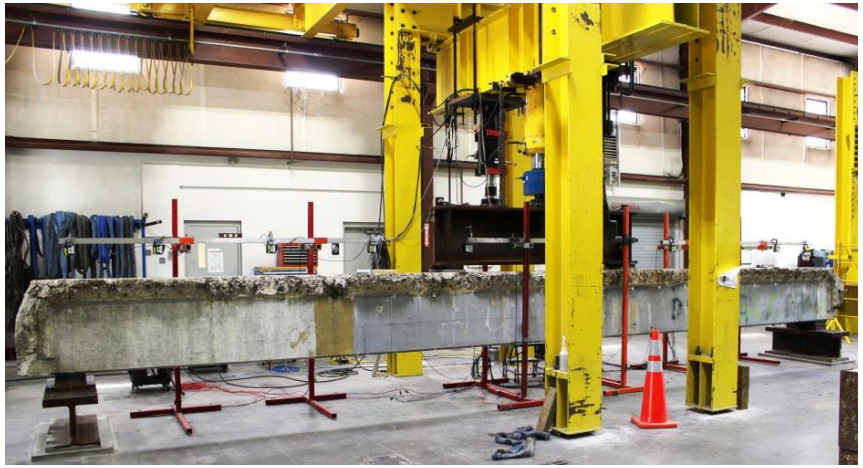
12% increase

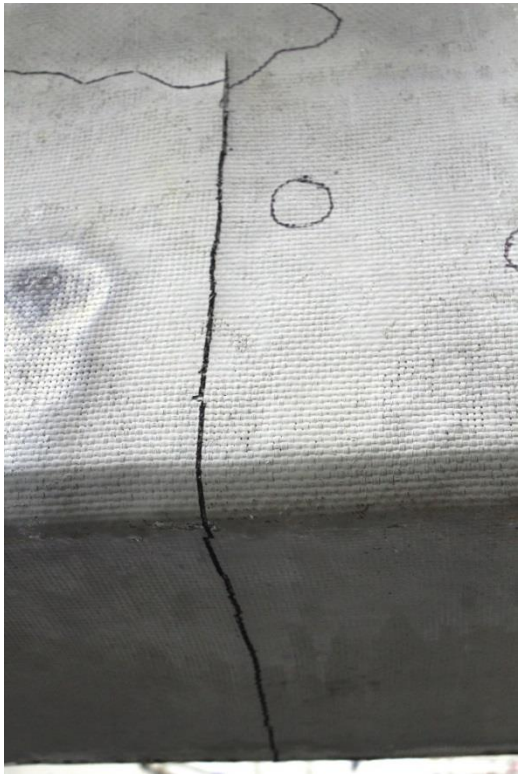
Girder #2



8% increase

Durability of FRP Repairs





Durability of FRP Repairs

- Additional Testing Completed
- Field Investigations Performed

Port of Tampa

University Blvd Bridge

Chaffee Road Bridge

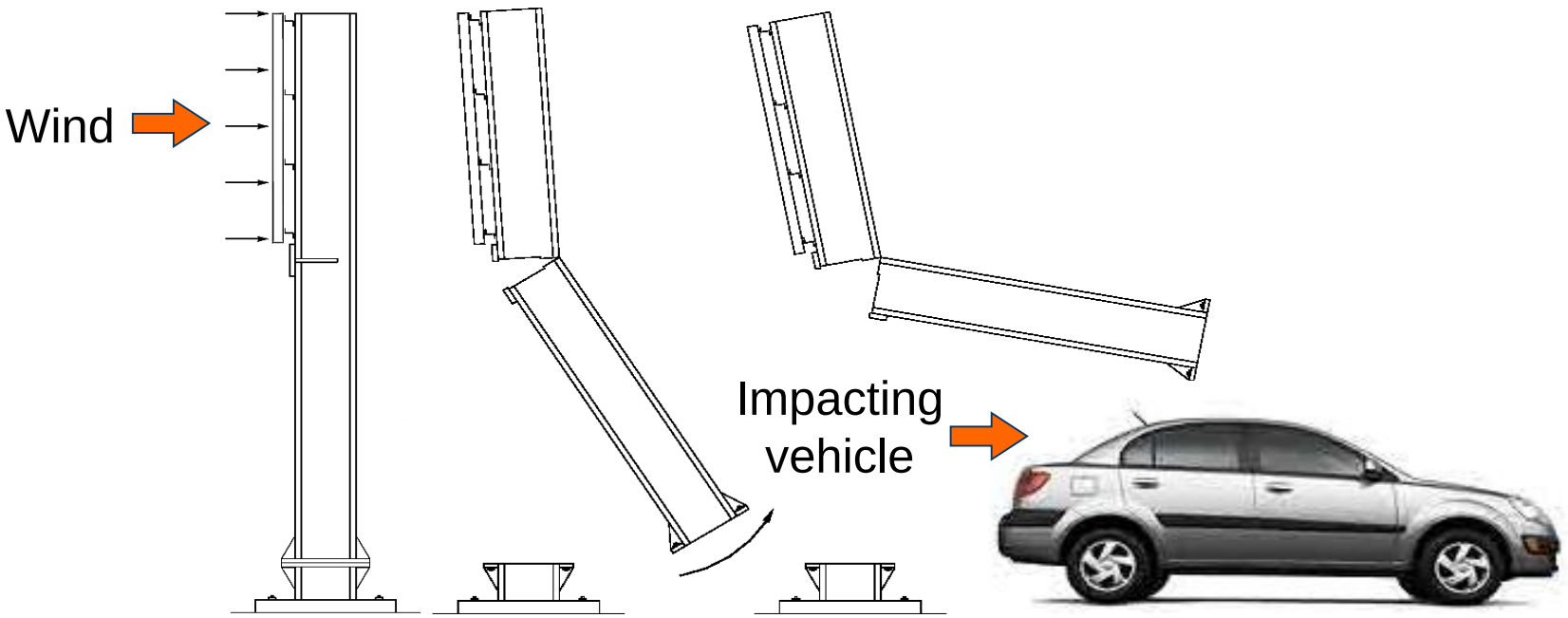
Phillips Lane

Turkey Creek

Dickman Road

Breakaway Sign Testing

- Scaling and Validation of Breakaway Connection



Wind load:
Sign survival

Vehicle impact:
Occupant survival

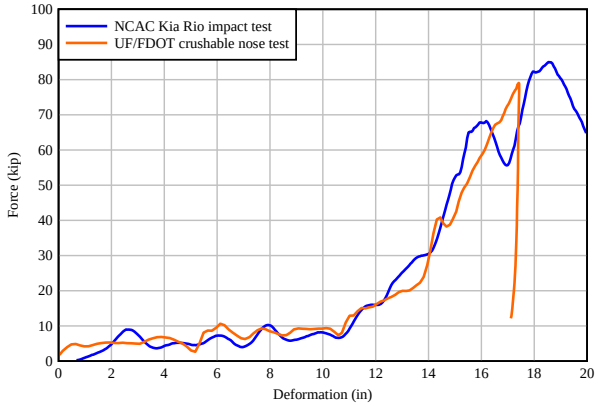
Breakaway Sign Testing

- MASH-compliant 1100C surrogate test vehicle

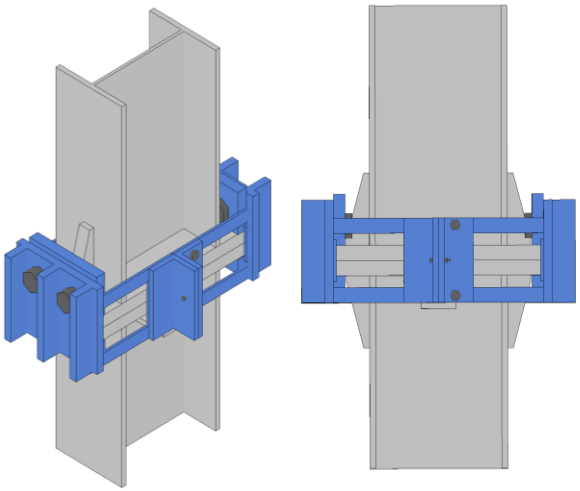
2006 Kia Rio (~1100 kg, ~2420 lbs)

1100C crushable-nose surrogate vehicle (impactor)

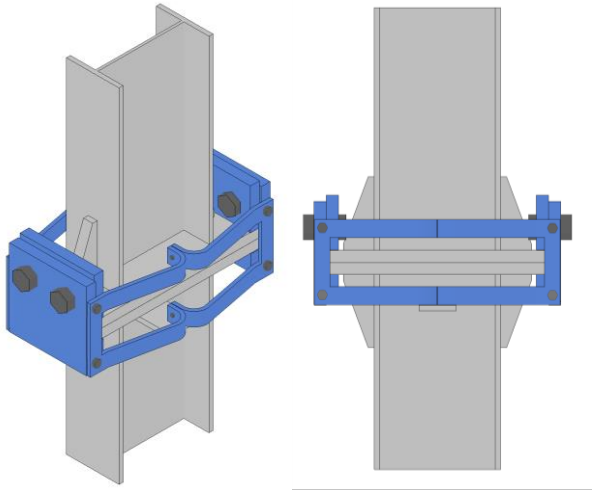
FDOT impact pendulum



Breakaway Sign Testing



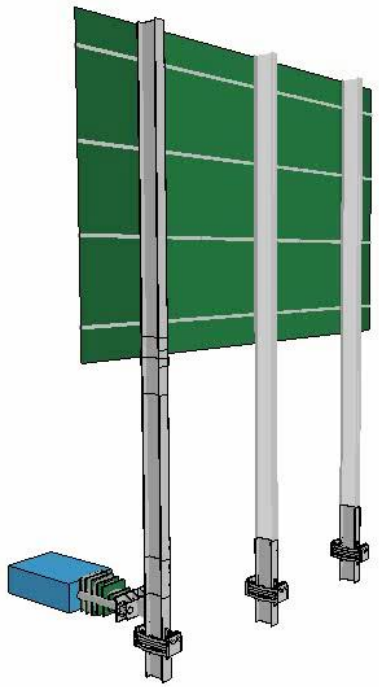
- Initial Research
- W12x40 Post
- Additional complexities with welds and elements



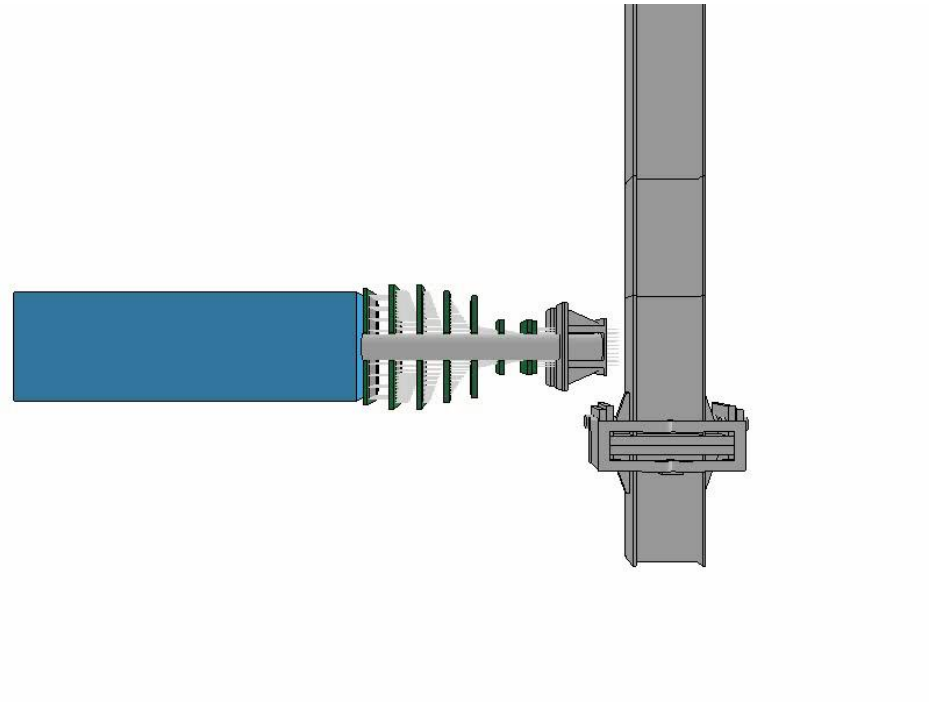
- Current Research Design
- W10x26
- Greatly reduced complexities in fabrication/installation

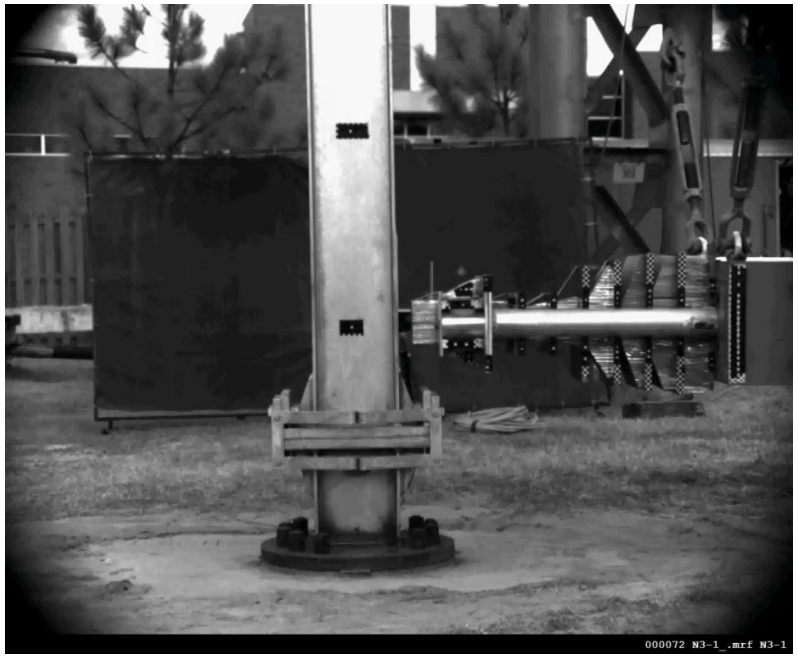
Breakaway Sign Testing

- Impact Performance Criteria – Set by AASHTO MASH
  - Occupant Impact Velocity and Occupant Ridedown Acceleration
  - 19 mph low speed impact at 0 and 25 degree impact angles
- Additional testing planned for low and medium capacity breakaway connections



Breakaway Sign Testing



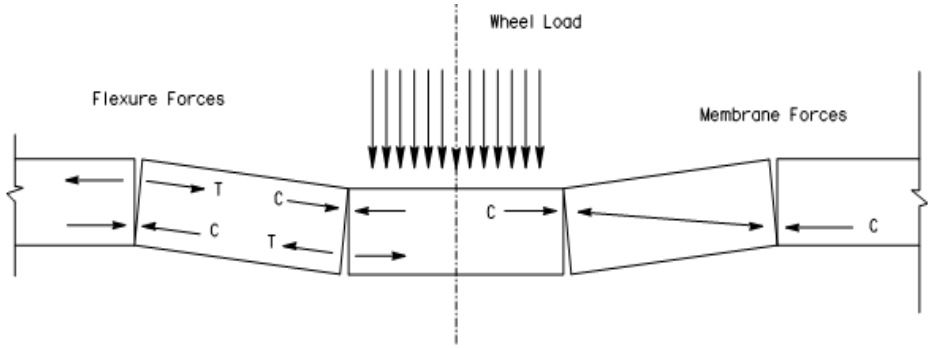


Empirical Deck for Phased Construction and Widening

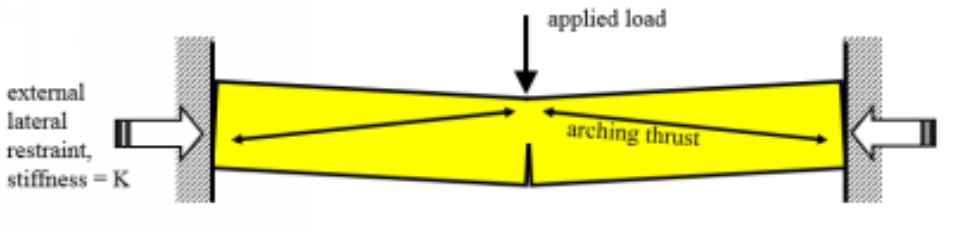
- AASHTO-LRFD Specifications
  - Empirical Design (9.7.2)
  - Traditional Design (9.7.3) – strip method
- Current FDOT Structures Design Guidelines
  - Empirical Deck Design is not allowed (SDG 4.2.4)
    - Incorporated into the 2010 SDG
  - Rationale: potential for future widening or phased construction and associated traffic control impact
- Empirical Deck Steel per AASHTO LRFD
    - Bottom Layer – 0.27 in^2/ft (0.28% - 8" deck)
    - Top Layer – 0.18 in^2/ft (0.19% - 8" deck)
    - Spacing not to exceed 18 inches

Empirical Deck Project

- Empirical Deck Methodology
  - Internal Arching/Compressive Membrane Action
  - Failure mechanism in concrete bridge decks is generally punching shear.



(Caltrans, 2015)



(Rankin, 1982)

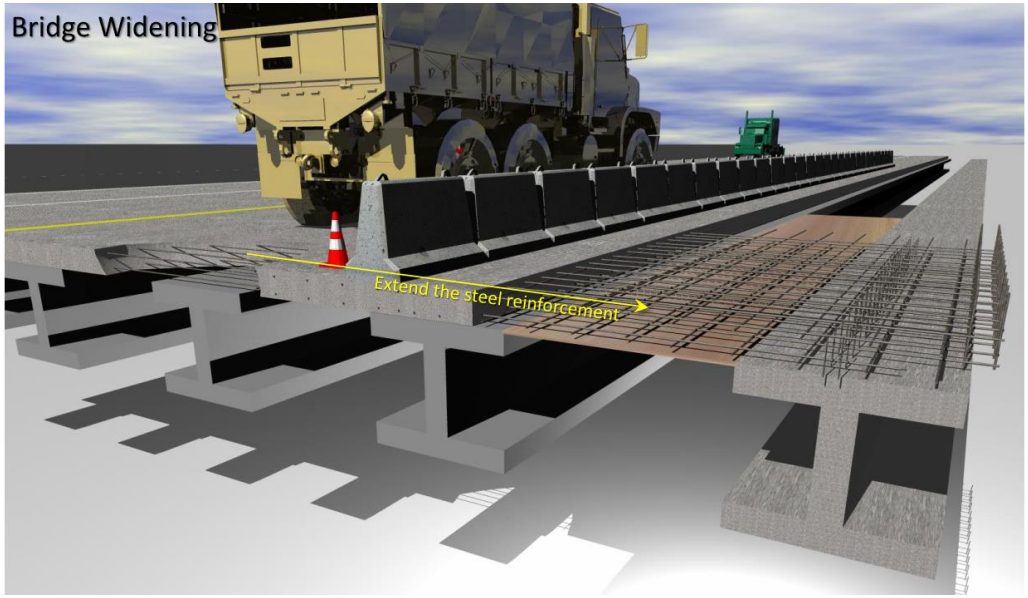
Empirical Deck Project

- Phased Construction and Widening

AASHTO Design Conditions

There is an overhang beyond the centerline of the outside girder of at least 5.0 times the depth of the slab; this condition is satisfied if the overhang is at least 3.0 times the depth of the slab and a structurally continuous concrete barrier is made composite with the overhang;

Cross-frames or diaphragms are used throughout the cross-section at lines of support;



Empirical Deck Project

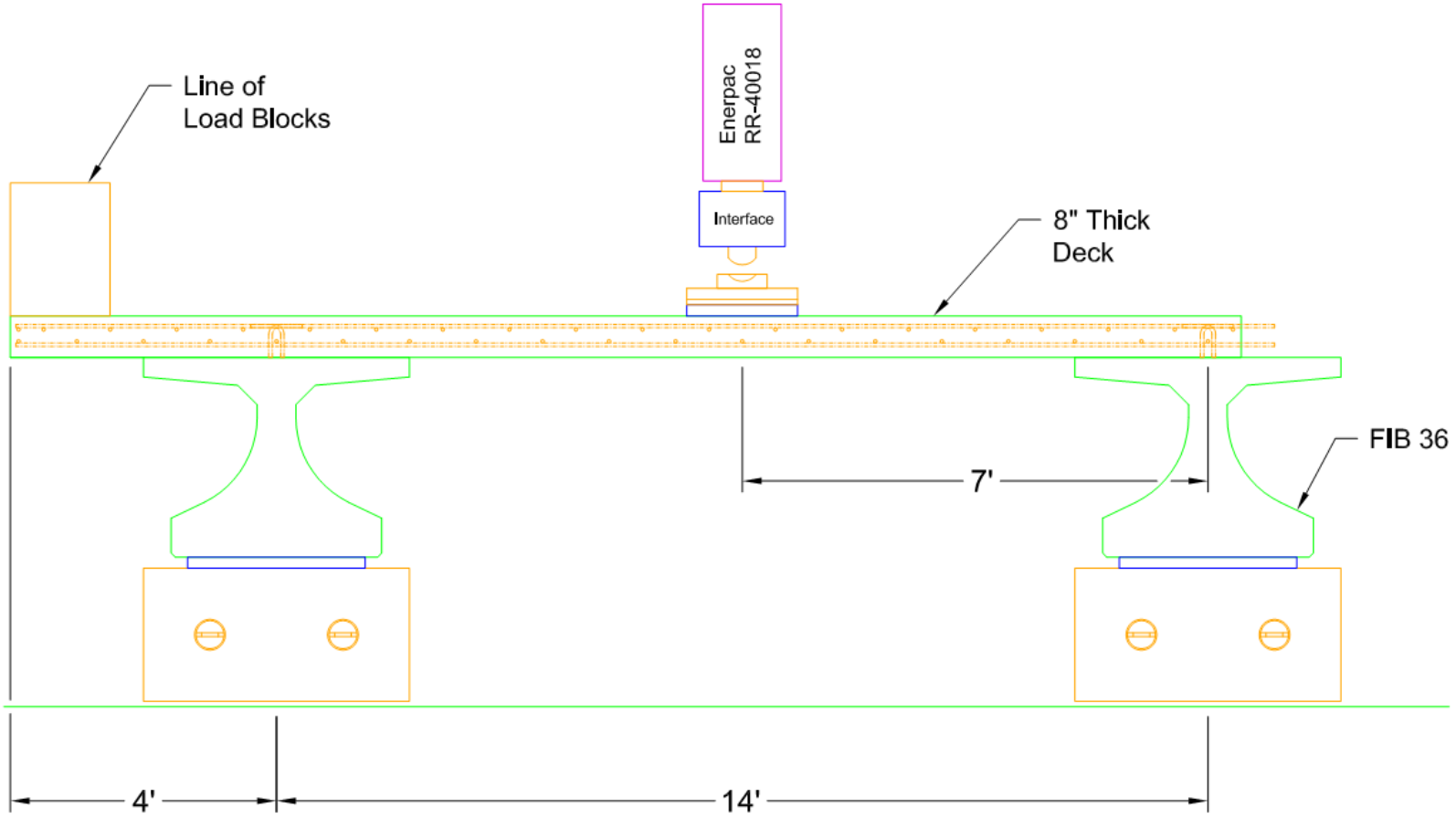
- Use on Florida I-beam
  - Wide Top/Bottom Flanges/Increased Weak-axis Inertia
  - Allows for higher rigidity to assist in the arching action.
- Evaluation of Variables (Analytically)
  - Girder Spacing
  - Span Length
  - Slab Thickness
  - Concrete Strength - f'c
  - Lateral Stiffness
  - Reinforcement Ratio

Empirical Deck Project

- Concept Deck Testing
  - FIB36 – 47-ft Girder Length
  - 14-ft Beam Spacing
  - 8-inch Deck Thickness
  - Simulated Widening
  - No Diaphragms or Thickened Slab
  - 2 Girder System
  - Load Area – 10” x 20”
  - Deck Reinforcement - #5 @ 12” – 0.31 in^2/ft
    - Top and Bottom Each Direction
    - 0.3% for both top and bottom (0.64% total)

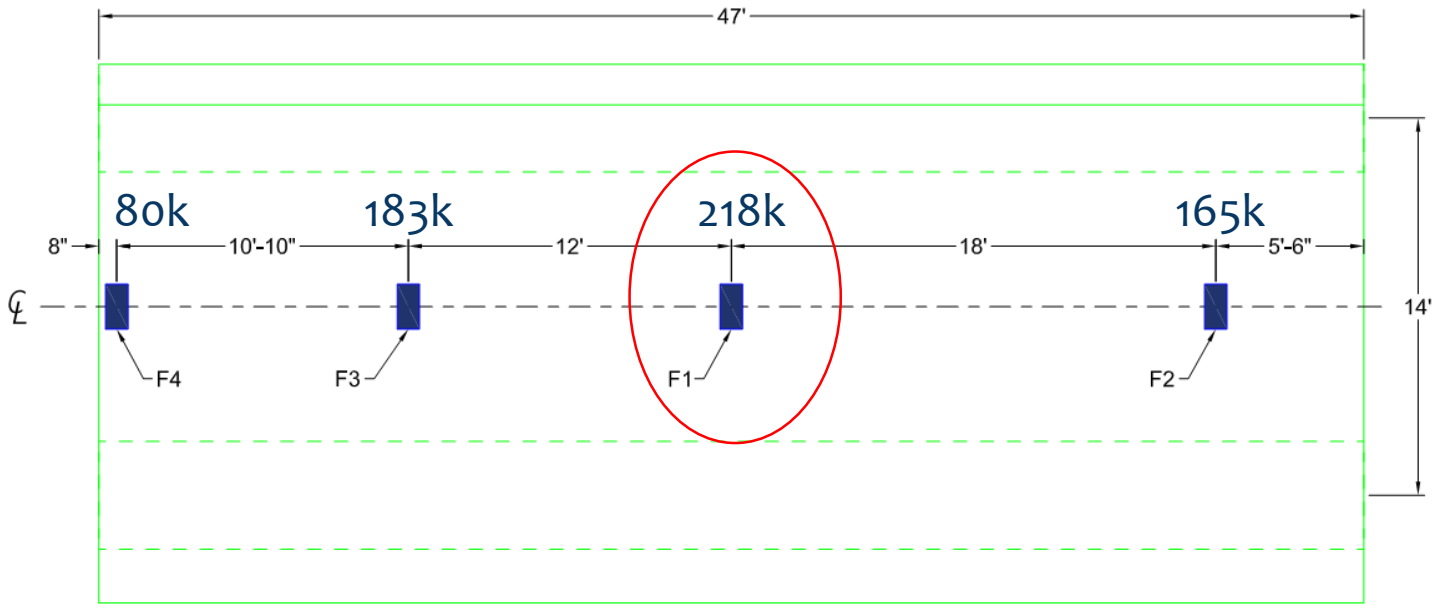
Empirical Deck Project

Empirical Deck Project



Empirical Deck Project

- AASHTO Wheel Loads
  - (1.75)(16k)(1.33) = 37.2 kip
  - (1.0)(16k)(1.33) = 21.3 kip



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Empirical Deck Project

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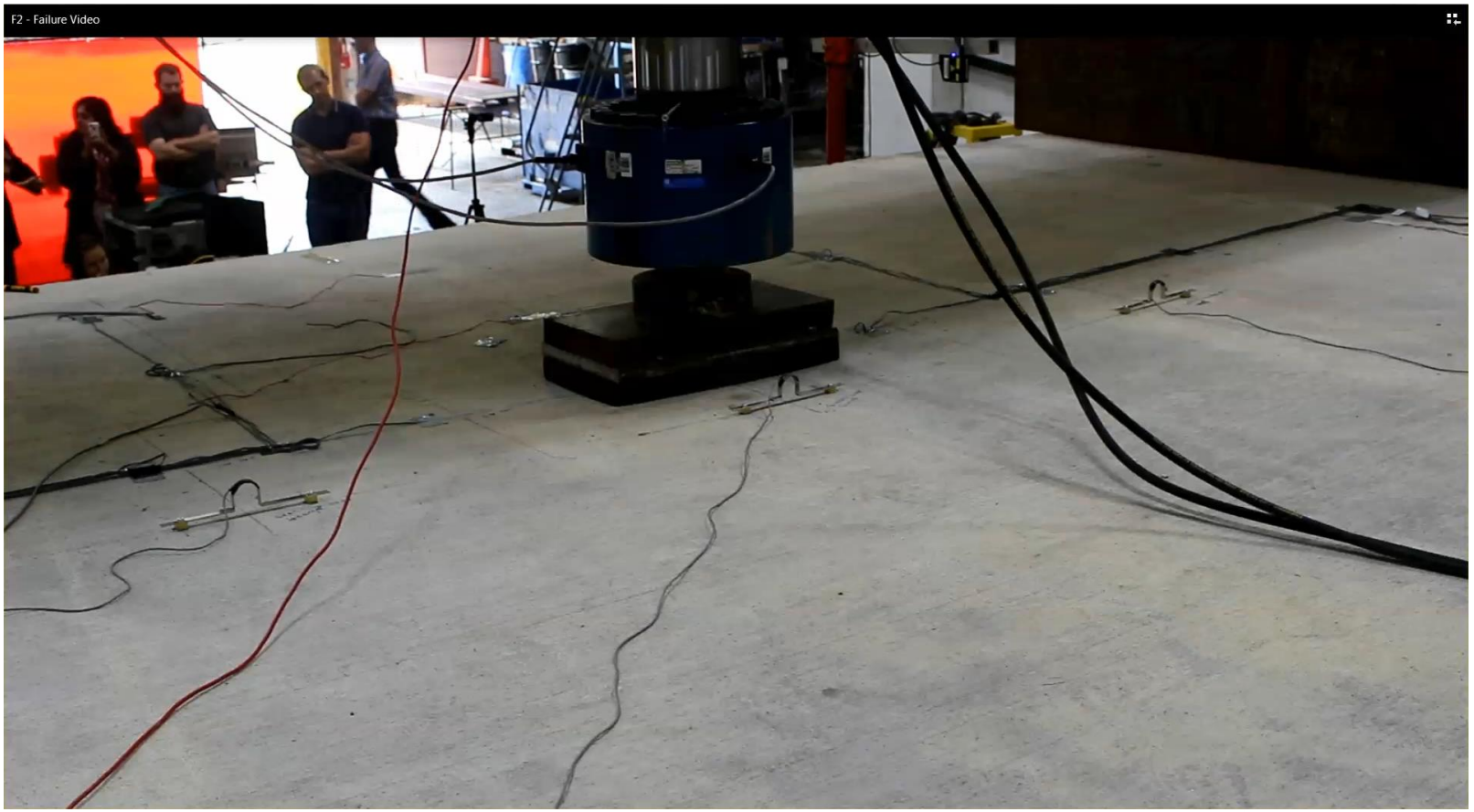
Empirical Deck Project



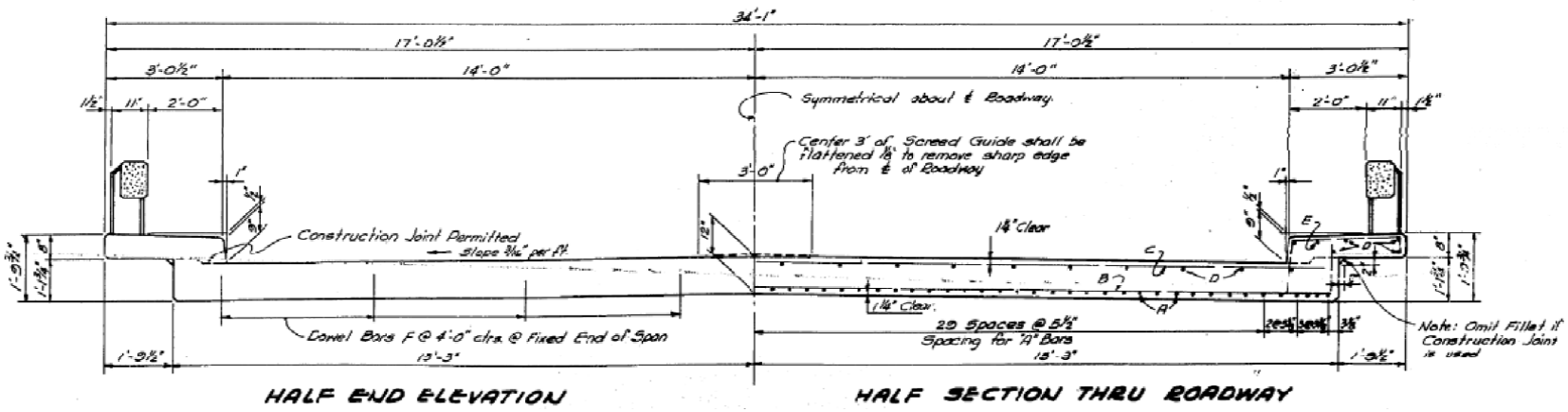
Empirical Deck Project

Empirical Deck Project

- Development of SDG Language (Contingent)
  - Allow use of Empirical method on the Florida I-beam
  - Reinforcement Options
    - #5 @ 12” or #4 @ 8”
    - Stagger spacing of top and bottom reinforcement
  - Cross-frames or diaphragms are not required at the supports.
  - An overhang is not required for girders for the temporary condition of phased construction or widening.
  - Overhang design is the same as conventional decks.

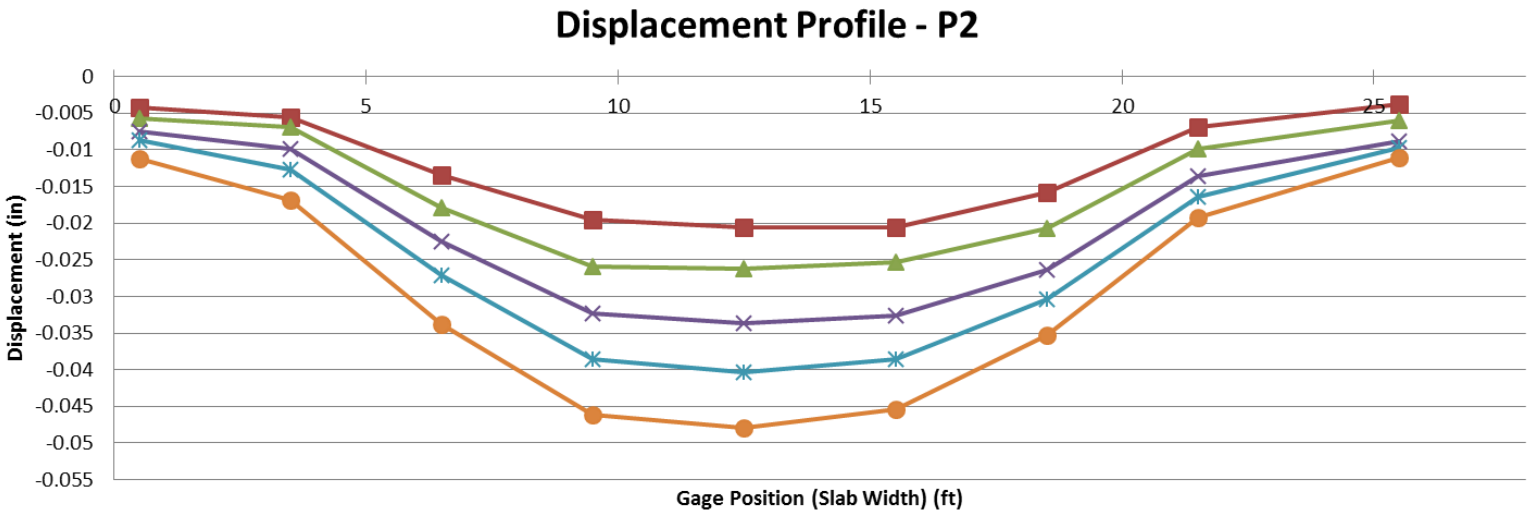
Flat Slab Evaluation

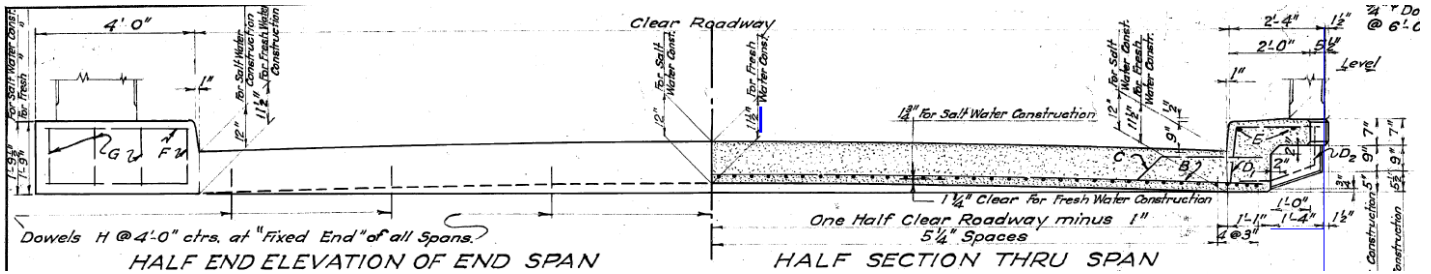
- Objective
  - Evaluate the effective strip width distribution both analytically and thru field load testing.
  - Provide written guidance for the FDOT Bridge Load Rating Manual.



Flat Slab Evaluation

- Bridge Load Test





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Questions